Feedwater Quality

Feedwater Sources

Two sources supplied feed water to the plant. The first source referred hereinafter as *tile drain water* was used during 2000. Tile drain water, as the name implies, came from a tile drain system constructed beneath the root zone of the crops. Water that percolates through the crop root zone is collected by the tile drain system and is emptied into a sump. A sump pump delivers the drainage water to the RO demonstration plant. Refer to **Figure 2** for the location of the tile drain system and the RO demonstration plant.

The second source, hereinafter referred to as *well water* was used in 2002. Well water was supplied by two wells drilled after flows too low to operate the demonstration plant were experienced in 2001 with tile drain water. These wells pump water from the same aquifer as the tile drain system but from a deeper depth so that fluctuations in groundwater depth have less impact than with a tile drain system. The depth of the two wells is about 80 feet. The two wells are referred to hereinafter as the North Well and the South Well (100 gpm each).

Piezometers

In 2002, five piezometers were installed to monitor the effects on the groundwater elevation resulting from operation of the North and South Wells. The piezometers are located as shown on **Figure 3:**

- #1, #2, and #3 (between the North Well and the South Well):
- #4 (north of the North Well); and,
- #5 (south of the South Well).

These five piezometers supplemented five existing piezometers:

- #30 (northwest of the North Well);
- #31 (northeast of the North Well);
- #35 (southwest of the South Well);
- #36 (southeast of the South Well); and,
- #38 (southeast of the South Well).

Figures G-1 through **G-4**, located in **Appendix G**, show surface and groundwater elevation contours for the September 2001, December 2001, September 2002, and December 2002. The North and South Wells were drilled in December 2001 and operated during 2002.

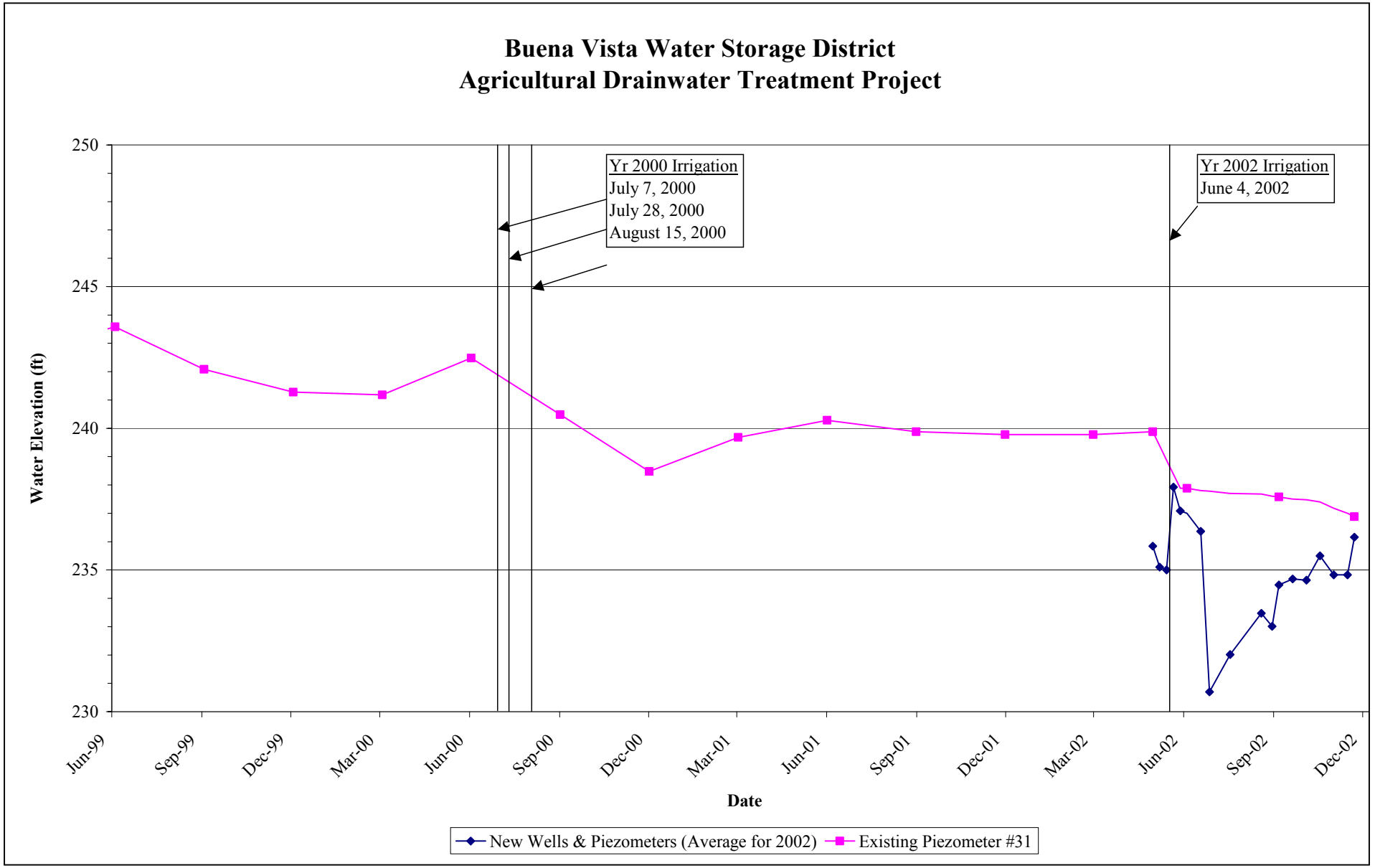
Table 2 shows the depths to groundwater for piezometers #30, #31, #35, and #36 and for the North and South Wells based on the information in **Figures G-1** through **G-4.**

Table 2

Depth to Groundwater (feet)					
	Piezometers				North and South Wells
Date	#30	#31	#35	#36	
9/01	8	8	7	8	6
12/01	7	9	6	9	6-7
9/02	10	8	9	7	13-15
12/-2	10	10	11	10	12-13

Figure 4 shows the water surface elevations recorded at piezometer #31 for the period June 1999 through December 2002. In addition, the figures shows the water surface elevations measured at the North and South Wells during the months in 2002 when the demonstration plant was operated.

Figure 4. Change in Groundwater Elevation Through 2002



Feedwater Quality

Feedwater quality affects the performance of any treatment process including RO. The more important quality parameters of RO feedwater include total dissolved solids, electrical conductivity, total suspended solids, silt density index, and pH.

- **Total Dissolved Solids (TDS)** - TDS is a measure of the dissolved substances in water such as calcium, magnesium, sodium, potassium, chloride, sulfate, bicarbonate, and nitrate. TDS removal is the primary objective of the RO process. Dissolved solids test results are reported in terms of milligrams per liter (mg/L).

- **Electrical Conductivity (EC)** - The electrical conductivity is a temperature dependent indication of the TDS of the water. EC is either expressed as milli-Siemens per centimeter or micro-Siemens per centimeter (mS/cm or µS/cm), and it can be used as an analogous measure of TDS. In this report, the values for EC are reported in both mS/cm and µS/cm. Values reported from the laboratory were taken at 25^{o}C while all values taken in the field were temperature compensated.

- **Total Suspended Solids (TSS)** - TSS is a measure of the undissolved suspended substances in water. TSS can be a wide variety of suspended organic and inorganic materials. Suspended solids test results are reported in terms of milligrams per liter (mg/L).

  - ***Turbidity*** – Turbidity is an indirect measurement of the suspended solids present in water. It measures the amount of light scattered by the particles suspended in the water. The presence of turbidity in the feedwater to the RO system above 0.5 nephelometric turbidity units (NTU) indicates material in the water that may foul the RO membranes and is a performance goal measure for filtration processes.

- **Silt Density Index (SDI)** – SDI measures the level of materials in the water that will plug a 0.45 μm[1] filter. It is an indicator of the fouling potential a particular water source has on RO membranes. Typical RO membrane warranties require that SDI remain below 4.

- **pH** - pH is a term used to express the intensity of the acid or alkaline condition of a solution. The pH scale ranges from 0 to 14. Acidity increases as pH declines from 7 to 0. Alkalinity increases as pH increases from 7 to 14. Acceptable pH range in household water lies between 6.5 and 8.5.

After switching the source of the RO plant feedwater from the tile drain to the new wells, the quality of the RO feedwater changed. The well water quality was better than the tile drain water quality. The only exception was TSS, where water from the tile drain system contained less TSS than water from the wells. This did not impact RO permeate (desalted water) quality as the plant's pretreatment filtration system produced water with acceptable SDI for both water sources.

Table 3 presents average water quality for the years shown. Complete water quality data is presented in **Table 5** for the feed and product streams and in **Table 9** for the concentrate stream.

Table 3. Comparisons of Source Water

Feed Water (Irrigation Period)	**Yr. 2000** (Tile Drain)	**Yr. 2002** (Wells)
TDS (mg/L)	7,010	3,980
Feed EC (mS/cm)	10.2	6.2
TSS (mg/L)	4.0	4.4
Turbidity (NTU)	12.4	17.4
SDI (after filtration)	2.77	1.94
Feed pH	7.3	7.1

[1] μm = micron = one millionth of a meter = 0.00004 inches.

Shallow Water Characteristics

The quality of the shallow water collected by the tile drain system varied throughout the 2000 irrigation season. As shown in **Figure 5,** the SDI and conductivity (EC) values were influenced by application of irrigation water. Note that all SDI values were taken after filtration.

During the irrigation periods, the EC values decline and the SDI values of the filtrate increase. This happens because fresh water flows into the zone from which the tile drain system collects water diluting the salty water. Dilution causes a decrease in the conductivity of the feed water.

Furthermore, as the fresh water percolates through the soil, it carries suspended solids into the tile drain system. The addition of these suspended solids causes the SDI of the filtrate during irrigation periods to increase.

The tile drain may be generally characterized as moderately saline with low turbidity. Data taken during the year 2000 showed that the average turbidity of the tile drain water was12. Filtration ahead of the RO equipment was required because RO requires feedwater turbidity of less than 1 NTU.

Appendix A, 2000 Demonstration Plant Data, contains information on the demonstration plant using tile drain water to supply the demonstration plant feedwater.

Figure 5: Filtrate SDI and EC History for 2000 (Tile Drain)

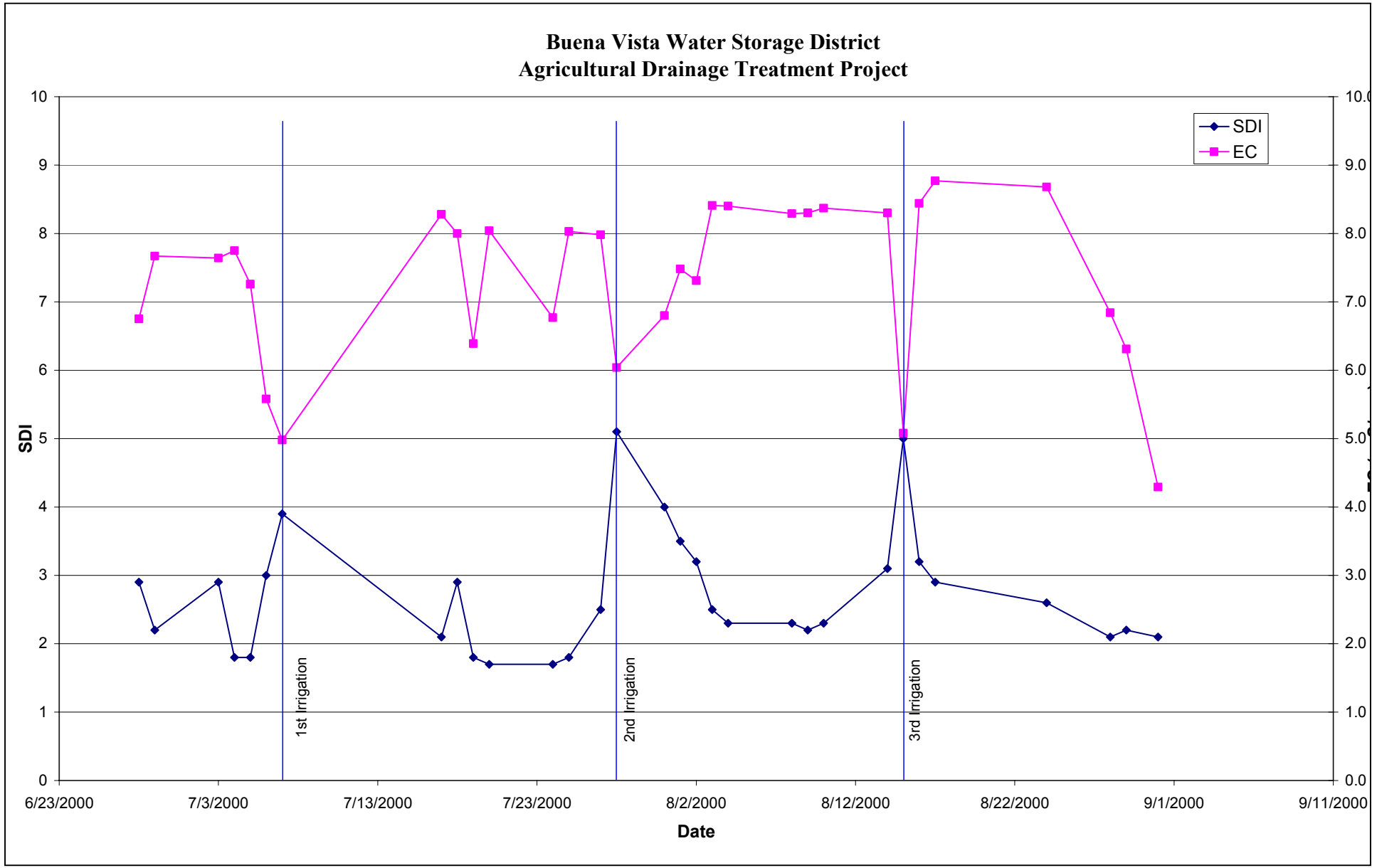
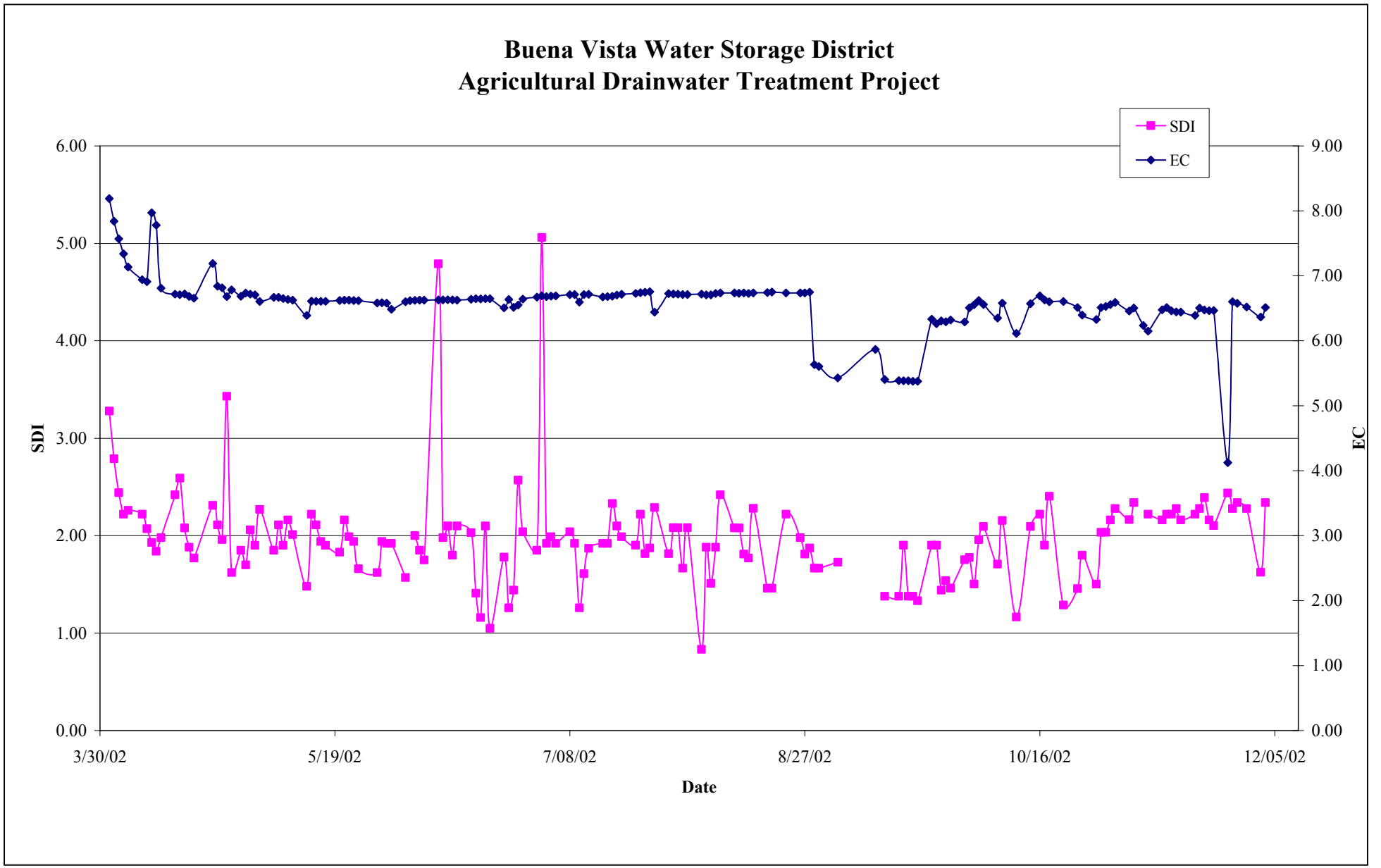


Figure 6: Filtrate SDI and EC History for 2002 (Well Water)



Well Water Characteristics

The water supplied to the RO demonstration plant during 2002 came from the two wells drilled during the winter of 2001. As shown in **Table 3**, the well water had lower TDS than the tile drain water.

Because the North and South Wells pump from deeper within the saline aquifer, there is less impact resulting from irrigation on EC and filtered water SDI as compared to the tile drain water (see **Figure 6**). Whereas the EC of the tile drain water varied from about 4.3 mS/cm to almost 9.0 mS/cm (see **Figure 5**), the EC of the well water was about 7.7 mS/cm during most of the time the demonstration plant was operated in 2002. And, whereas the SDI of the filtered tile drain water was widely variable (see **Figure 5**) and averaged about 2.8, the SDI of the filtered well water was reasonably consistent and averaged less than 2.0.

Water quality data for the well water is presented in **Appendix B**.